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Wide Tunability and Large Mode-Suppression in a Multi-section Semiconductor Laser using Sampled Gratings

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Summary

We have recently proposed [1,2] a 4-section semiconductor laser which is capable of tuning over several tens of nanometers. A schematic of this device is shown in Fig. 1, along with the reflection spectra of the two mirrors which form the backbone of this device. These two mirrors consist of "sampled" gratings with mismatched periodic reflection spectra, as indicated in Fig. 1. Lasing in this structure occurs where two reflection maxima are aligned. By inducing index changes in one mirror relative to the other, adjacent reflectivity maxima can be brought into alignment, resulting in wide-range discontinuous tuning with very small index changes. Wavelength coverage between the maxima can be obtained by inducing identical index changes in the two mirrors, and adjusting the phase-shifter appropriately, much like 3-section lasers [3].

For our initial concept demonstration [2], we fabricated an all-active 2-section structure using liquid phase epitaxy (LPE). This device exhibited 29.3 nm of tuning but only 10 dB of mode suppression due to a weak grating. More recently, we have fabricated devices using metal-organic chemical vapor depostion (MOCVD). These devices incorporate a large kappa grating and show correspondingly large mode-suppression. A schematic of our device structure is shown in Fig. 2. The device (fabricated as a 50μm broad-area stripe) has two sections, a multi-quantum well active region using 4 wells, and sampled gratings etched in the upper 1.38 quaternary layer with two sampling periods in the two sections. The device was tested as-cleaved, with no anti-reflection coatings. This device is designed to exhibit discontinuous tuning in multiples of approximately 7 nm, which corresponds to the spacing of maxima in the reflection spectrum, for the sampling period indicated in Fig. 2.

Figure 3 shows time-averaged optical spectra of our best device under pulsed operation at 4 single-mode locations (on a log scale) over a tuning range of 22 nm. As can be seen, the single-mode locations are separated by approximately 7 nm, and the mode suppression for 2 of the 4 spectra exceeds 40 dB. The tuning range in this all-active device is limited by carrier clamping, which occurs at fairly low carrier densities due to the strong grating and uncoated facet reflections. Such would not be the case, of course, in the "ideal" active/passive structure of Fig. 1. Simulations for the active/passive device predict roughly 50 nm of tuning. Our calculations also indicate that the tuning range can be significantly increased even in an all-active structure, by reducing the mismatch between sampled gratings and incorporating 3 instead of 2 sections. Such all-active structures, in addition to providing easily fabricated test vehicles for the sampled grating concept, also offer promise of reduced spontaneous emission and narrow linewidth. In this paper we will present experimental tuning results in structures with both 2 and 3 sections, and with optimized sampled grating parameters.

References

1. V. Jayaraman, D.A.Cohen, and L.A.Coldren, *Leos '91*, paper SDL15.5, San Jose, CA.
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3. K. Kobayashi and I. Mito, *IEEE JLT*, vol. 6, no. 11, November 1988.

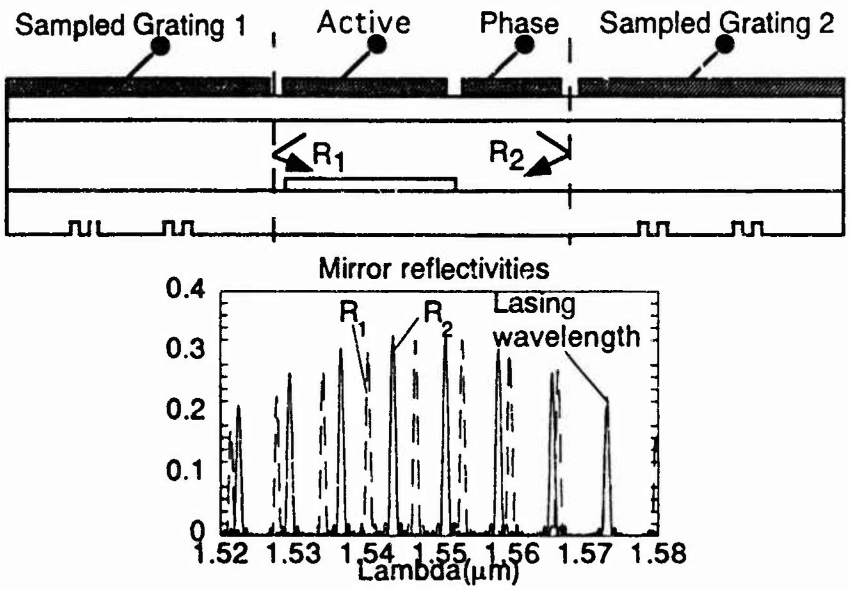

Figure 1: 4-section tunable laser and sampled grating reflectivity spectra

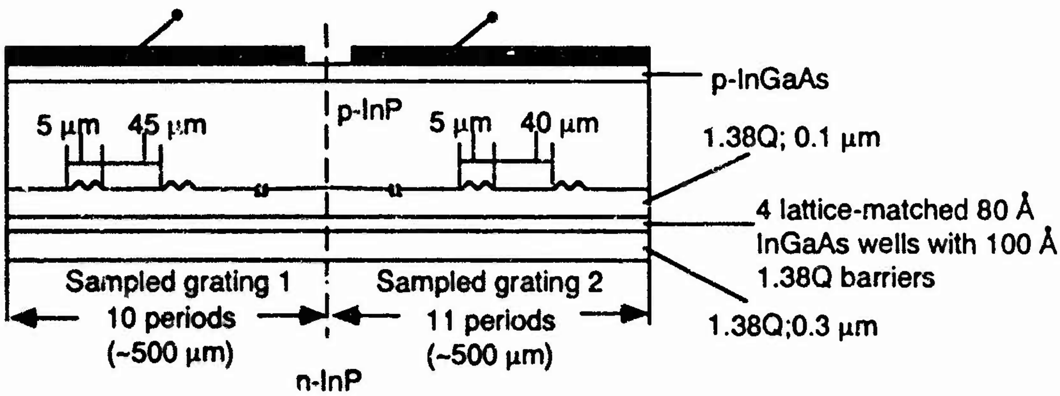

Figure 2: MOCVD-grown 2-section all-active sampled grating tunable laser

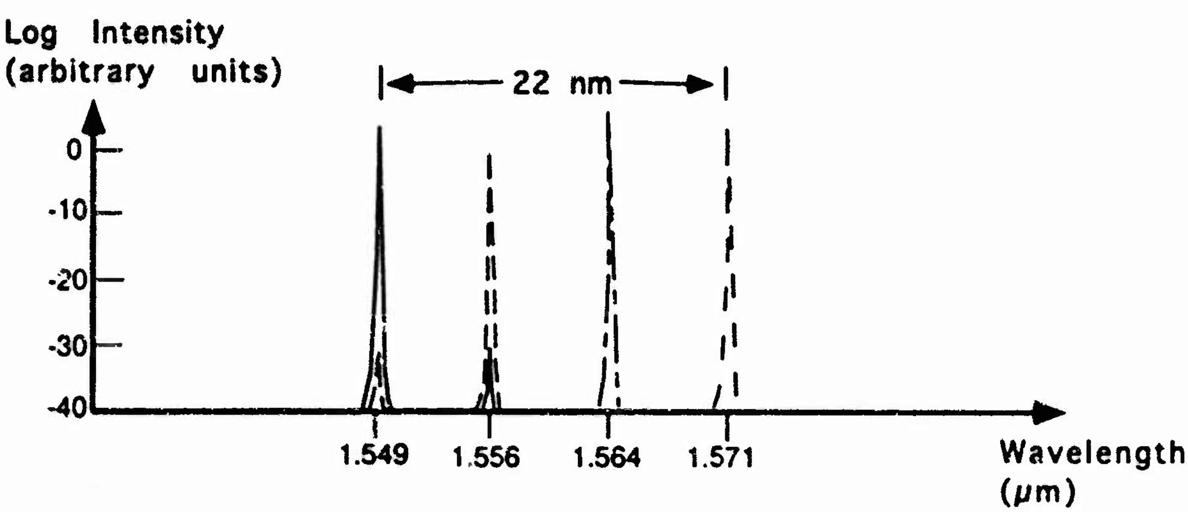

Figure 3: Time-averaged optical spectra for a broad-area device